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Behavioral Interactions in a Herd of Barbary Sheep
(*Ammotragus lervia*).¹

IRWIN KATZ.

The University of Buffalo.

INTRODUCTION.

Studies of social behavior in animals have generally been of two types, the naturalistic field investigation and the laboratory experiment. Field studies of ungulates have been made by Darling (5) on the red deer, and Mills (10), Davis (6) and Spencer (13) on the Rocky Mountain bighorn sheep. The experimental method has produced an extensive literature on dominance relationships and aggressive behavior in many species. Collias (4) has reviewed the work on aggressive behavior among vertebrates up to 1944. Studies on dominance have been too numerous even to be mentioned briefly in the present paper.

Carpenter (2) has pointed out that the development of a science of comparative social behavior requires that the results of field investigations and those of the laboratory should be systematically co-related. He also has stated that the standards of scientific research which apply in the laboratory can and should be applied in the field. Recognizing the research potentialities of an integrated approach to animal behavior, Scott (11) recently combined systematic observation and experimentation in a study of a small flock of domestic sheep living under semi-natural conditions.

The methods and aims of the following study of a herd of Barbary sheep were suggested in large part by the work of Scott and the theoretical discussions of Carpenter (2, 3). Carpenter (2) has listed 11 types of behavioral interactions found in primate societies. It was hoped that the first six of these might be studied in the Barbary sheep. They are: 1, Interactions among adult males of organized groups; 2, among adult females of organized groups; 3, between adult males and adult females; 4, between adult males and young; 5, between adult females and

young; and 6, among the young. The data were to be compared with information on the domestic sheep and the Rocky Mountain bighorn. In addition, the investigator sought to obtain data relevant to the hypothesis that deprivation is an effective instigator of aggressive behavior.

THE HERD.

The Barbary sheep, or aoudad (*Ammotragus lervia*) is very distinct in appearance from all other wild sheep, its most unique features being a mane of long hairs over the fore-quarters, the length of tail and the large size of the female's horns. Its color is uniform rufous tawny. The habitat of the Barbary sheep is the arid southern slopes and foothills of the mountains of North Africa, extending from near the Atlantic seaboard to Egypt. Lydekker (8) quotes reports that the animals go about in groups of four or five and may drink as seldom as once in four or five days.

The herd at the New York Zoological Park is descended from stock brought to the Park during the years 1901-1906. No new stock has been introduced since then. During the summer of 1947 the herd consisted of four rams, four ewes and four lambs. One of the lambs was a yearling, while the others were first-season. The sheep lived on an enclosed field of about two acres. They shared the field with two elands and a zebra. Human regulation of the activity of the sheep has been kept at a minimum by the Park authorities. Under normal circumstances the herd is fed about one and one-half buckets of grain, which is spread out on a large, flat rock at about 9:30 every morning. The elands and the zebra usually feed from a box some distance away, although they sometimes wander over to the rock and feed with the sheep. The grain ration is supplemented occasionally with hay, which is placed in one corner of the field. Vending machines in the Park provide special food pellets which visitors may throw through the fence. During the warm months the sheep regularly gather at the north fence in the afternoon to receive these pellets. The sheep tend generally to avoid the two elands and the zebra. In recent years a newborn lamb was killed by the male eland, and another by the zebra.

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METHODS.

Casual observations were made almost daily from mid-July until mid-September, and during all hours of the day, so that a complete picture of the daily routine could be obtained. Colored dyes were used to mark the individual animals until the observer could recognize them easily by differences in appearance and behavior. The following experiments were performed repeatedly: (1) tossing of bread between pairs to ascertain relationships of dominance-subordination; (2) placing of daily grain ration in a small box to study dominance-subordination relationships in a complex herd situation, as well as to provide observations on food sharing, fighting, and related phenomena; (3) frightening of the herd to elicit leadership and timidity. These experiments were carried out from July 22 to September 13. In addition, on two days a Bristol multi-pen recorder was employed in connection with the feed box experiment to ascertain the amount of time each animal actually fed from the box. Motion pictures were taken of types of behavior which had been previously recognized and described.

The study of social relationships was limited by the fact that the age and parentage of adult individuals could not be established with certainty. Although the Park maintains complete records of births and deaths, there is no provision made for identifying individual members of herds. It was possible, however, to know three ewe-lamb relationships on the basis of observed behavior.

DAILY ROUTINE.

The daily pattern of behavior of the herd was marked by fairly regular periods of alternating activity and rest. But this was greatly modified by changes in the weather, experimentation and marked variations in the supply of food from visitors. Usually in the early morning the sheep wandered about the field. Grazing was desultory, since other food was available. At about 9:00 A.M. the sheep generally gathered on an outcropping of broad, flat rocks situated on a hillock in the center of the field, and there they rested until 9:30 A.M., when grain was scattered on a nearby rock by the keeper. The sheep ate the grain peacefully, with very little butting or shoving. By 10:15 A.M. the sheep were either back at their earlier places on the rocks or were under a tree, where they remained until after the noon hour.

Shortly afterwards children and adults would usually begin to gather along the north fence. The movement of the sheep to the fence seemed to be associated with the size of the gathering of people rather than the hour. On days when very few people visited the Park the sheep might remain entirely away from the fence throughout the afternoon. Once at the fence, the herd remained there as long as pellets were given to them, usually until about 5:30 P.M. On hot after-

noons the males made occasional trips to a nearby water hole. Here they cooled themselves by sinking down into the shallow water and rolling in the mud.

In the evening the sheep wandered and rested until dark. The lambs played actively at this time by running and leaping on the rocks. During late August and September fighting and attempted breeding occurred among the males, and most frequently in the evening. At dusk the herd gathered inside or near a shed and bedded down for the night. Sometimes the sheep moved as a group, but consistent leadership was not apparent. In general, there was much independent movement among the ewes, rams and lambs.

MATCHING TESTS.

The matching tests were conducted every few days from July 22 until September 13 to determine dominance-subordination interactions between individual animals. Usually the tests were made in the afternoon, when the sheep were gathered at the north fence. By supplying several willing children with bread, and placing them along the fence, it was possible to disperse the sheep so that all or most of the possible pairings could be made among the rams, the ewes and the lambs. The matching of adults and lambs, or of rams and ewes, was not attempted after the first day because of practical difficulties.

The matching test was simple. The experimenter stood at the fence and held a small piece of bread in his extended hand. When two sheep, which were not more than ten feet apart, looked in the direction of the experimenter, the bread was tossed so that it landed approximately equidistant between them. No score was recorded unless both animals moved toward the bread. The one which obtained possession of the bread by causing the other to withdraw was considered dominant. The behavior elicited in this situation was clear and unambiguous; if both sheep advanced toward the food, one *always* threatened or butted and the other *always* withdrew. Sometimes the bread landed much closer to the animal known to be subordinate. In such a case the subordinate sheep might obtain the bread, but this was usually followed by vigorous butts from the dominant animal. Often, however, a quick dash by the dominant sheep caused the other to retreat, even when the bread lay directly at its feet.

On three occasions the sheep appeared to be uniformly unmotivated with regard to the bread. Two of these days were extremely hot, and the third was marked by a morning of heavy feeding. At all other times competition was keen and sustained. The method of scoring is somewhat defective in that no scores were recorded for those tests in which only one animal moved toward the food. The assumption here is that of "no contest" and this is, of course, questionable, since the animal's lack of a positive overt response to the food might be due to the presence of the dominant animal. However, the almost per-

fect consistency of the results presented in Table I, and the agreement between these results and behavior observed in other situations strongly suggest that the method is highly valid.

In the majority of contests, dominance was decided by a sudden *twisting movement* of the dominant sheep's head in the direction of the other sheep. At this "signal" (or sign) the subordinate sheep stopped advancing. Sometimes a token butt was delivered, but seldom was a more forceful attack necessary to effect retreat. Counter attacks by subordinates occurred rarely and were *never* successful. Among the rams, the ewes and the lambs straight line dominance orders were revealed on the first day and remained almost stable during the 53-day period of testing. Only two instances of reversals occurred during a total of 272 matching tests. Although interactions between rams and ewes, and between adults and lambs, were not formally tested, it was apparent that *all rams were dominant over all ewes, and all adults over all lambs*.

The results of the matching tests are presented in Table I. The dominance order is as follows: Ram 1 > Ram 2 > Ram 3 > Ram 4 > Ewe 1 > Ewe 2 > Ewe 3 > Ewe 4 > Lamb 1 > Lamb 2 > Lamb 3 > Lamb 4 >. The attempt was to test at least twice a week every possible combination of individuals within each of the three subgroups. But this could not always be done because of the difficulty of bringing certain of the sheep together. For example, matchings between lambs were often disrupted by the sudden approach of one or more adults.

FEED BOX EXPERIMENTS.

The feed box experiments were intended to furnish information on social behavior in a competitive group situation. The matching tests had indicated the existence of a clear, stable relationship between any two animals which were made to compete for a small food object while in relative isolation from the other members of the herd. But it could not be assumed that these relationships would hold in all types of competitive situations, especially in those where more than two animals are interactive. Maslow (9) found that stable dominance-submission relationships which were established between monkeys by the method of paired matching tests broke down when three or more individuals were placed together.

The food incentive box was heavy and made of wood, typical of those used in the Park for the feeding of large animals. Its sides were about two feet long and about one and one-half feet high. The box was modified so that the interior sides measured 15" by 12", with the depth remaining unaltered. The interior was large enough to hold more than a bucket of grain without spilling by the feeding animals. The size of the opening was such that two adults could not feed simultaneously without frequent contact, while simultaneous feeding by three

TABLE I.
Results of the Matching Tests.

Rams*	Number of matchings
1-2	25
1-3	20
1-4	22
2-3	22
2-4	21
3-4	12
4-2†	1
2-1†	1
Ewes*	
1-2	22
1-3	18
1-4	15
2-3	15
2-4	13
3-4	9
Lambs*	
1-2	7
1-3	6
1-4	5
2-3	12
2-4	10
3-4	14
Groups	Total
Rams	124
Ewes	94
Lambs	54

* Numbers indicate sheep according to position in dominance order. Number of dominant animal precedes that of subordinate.

† Reversal.

adults would result in almost constant contacts. It was hoped that food sharing, and the conditions surrounding this behavior might result as well as competition for food.

The feed box experiment was conducted 12 times. On mornings when the experiments were performed, the experimenter moved the elands and the zebra from the field to adjacent pastures. At about 9:30 or 10:00 the box was placed on the rock where grain normally was scattered by the keeper. Then the experimenter emptied one bucket of grain into the box and withdrew behind a gate about 20 yards away. The sheep were observed by means of binoculars and their behavior was recorded immediately in a note book. Usually at the end of an hour it was necessary to place more grain in the box.

The general pattern of social interaction at the feed box was similar throughout the entire series of experiments. During the series of group tests an order of dominance was formed which conformed closely to that observed during the matching tests. Rams 1 and 2 always dominated the other animals at the box during the first 15 or 20 minutes of feeding. The other sheep milled around the feed box but were not permitted to eat. *The two dominant rams ate alternately.* Whenever Ram 1 raised his head to chew or rest, Ram 2 ate from the box. As Ram 1 again lowered his head, Ram 2 usually withdrew his head. A high degree of orderliness usually characterized the feeding of these two sheep. Often Ram 2 did not withdraw until

he was threatened or mildly butted by Ram 1. In the main, Ram 1 butted and shoved Ram 2, and the latter in turn kept the other sheep from the box. Upon being forced from the box by the more dominant animal, Ram 2 might circle the box and butt all the sheep in his path.² After the first few minutes the other animals ceased to crowd around the box. Some of them moved to a nearby tree and others formed a wide circle about the feeding place.

When he had completed his first feeding, Ram 1 left the feeding area. Ram 2 would either leave at the same time, or continue feeding. Then Ram 3, or Rams 3 and 4 together, moved up to the box, and interactions very similar to the previous ones were exhibited. During the first 30 or 40 minutes the box was controlled constantly by a pair of rams. But after the initial feeding of Rams 1 and 2 the pairings shifted frequently due to the movements to and from the box of dominant rams. From time to time ewes and lambs attempted to feed, usually with little success. The subordinate ram of a pair did most of the butting and chasing of the other members of the herd.

During the second hour the rams spent less time at the box, and when there manifested *increasing tolerance* toward the lambs and ewes. The order of feeding among the ewes was also determined mainly by dominance status, while a lamb's ability to feed depended on the tolerance of its own ewe. Often Ewe 4 and Lamb 1 (the yearling) obtained little or no food during an entire experiment. Being of low dominance status, the ewe was excluded, and the lamb likewise because it lacked high dominance maternal protection. The experiment usually ended shortly after the noon hour, when the sheep began to move toward the north fence for pellets offered by visitors.

Dominance. In Table II are presented the butts and threats given and received by each sheep during the series of 12 feed box experiments.³ Except for two instances, threats were always directed by dominant animals against subordinate ones. The butt more frequently was directed by a subordinate sheep against a dominant one. Nineteen butts, of a total of 198, fall in this category.

The data on rams in Table II indicate that the dominance-subordination relationships among these animals were somewhat less rigid and involved more behavioral interaction among individuals than in the matching tests. However, it must not be assumed that relationships at the feed box were less stable. Stability cannot be inferred from the ratio of butts given and received. Nor would

a mere tabulation of instances of food sharing and food hoarding provide a valid basis for inferring dominance status. For example Rams 1 and 2 usually ate together with little overt indication of dominance-subordination. Often they fed alternately for three or four minutes without observable conflict. But upon closer examination it could be seen that Ram 1 *permitted* Ram 2 to eat with him, and even to shove him occasionally. Over-vigorous shoving or persistent crowding on the part of Ram 2 always elicited a sharp attack from Ram 1. Exchanges of butts might be equal in number but they always ended with Ram 1 in control of the box.

Wide variations in the "social distance" between different rams are apparent. Reciprocity of aggression was relatively high between Rams 1 and 2 and between Rams 2 and 4, but Ram 3 never aggressed against Ram 1 or Ram 2, and was almost never aggressed against by Ram 4.⁴ The meaning of these differences in "social distance" will become clearer at a later point in the discussion. Among the sheep included in Table II, frequencies of butts and threats decrease in almost perfect rank order. The data on ewes and lambs has not been analyzed in detail because of the low frequency of aggressions. Lambs 2, 3 and 4 are not included in the Table only because their scores on both items were zero.

Feeding time. Scores for feeding time were computed from the Bristol recordings of an experiment on August 11 according to the method described in the first footnote to Table III. The time score for each sheep is the number of 10-second periods during which the animal had its head in the box for two seconds or longer. In Table III individual scores are given for each of nine consecutive periods. The periods are 16.6 minutes in length. Individual totals for the whole experiment indicate a lack of positive relationship between dominance status and feeding time, although the differences between rams and ewes, and adults and lambs, are on the whole substantial. The lack of relation between feeding time and dominance status may be due to wide individual differences both in rate of food intake and nutritional needs.

For most of the sheep there is a single period during which much more feeding occurred than during other periods. This would seem to justify a comparison of the periods in which individuals made their highest scores. Such scores have been indicated in the Table by a small circle. The circles follow a line which gradually descends from left to right, indicating that time-of-maximum-feeding is closely related to the dominance order. The near-zero scores of Ewe 4 and Lamb 1 have already been discussed.

Coordinate-feeding. An important type of social interaction among the sheep was that of coordinate-feeding, or food sharing. The concept and the unit of measurement employed are described in the first footnote to

² These attacks by Ram 2 against subordinate sheep appeared to be clear instances of *displaced aggression*, and will be discussed later on in this paper.

³ A threat is defined as an aggressive movement or pattern of movements which one sheep directs at another, but which does not end in physical contact. The typical threat consisted of a sudden lowering of the head and slight movement toward the other animal. But sometimes a mere lowering and twisting of the head composed the pattern. The object of a threat usually withdrew immediately or modified his behavior in some observable way.

⁴ See footnote to Table II.

TABLE II.

Total Butts and Threats for 12 Feed Box Experiments*.

	Threats						Butts					
	Recipients						Recipients					
	Ram #1	Ram #2	Ram #3	Ram #4	Ewes & Lambs	Total	Ram #1	Ram #2	Ram #3	Ram #4	Ewes & Lambs	Total
Ram #1	x	21	1	2	21	45	x	42	5	5	15	67
Ram #2	0	x	4	2	16	22	9	x	2	13	16	40
Ram #3	0	1	x	8	11	20	0	0	x	14	19	33
Ram #4	0	0	1	x	18	19	0	8	2	x	15	25
Ewe #1	0	0	0	0	5	5	0	0	0	0	17	17
Ewe #2	0	0	0	0	6	6	0	0	0	0	12	12
Ewe #3	0	0	0	0	0	0	0	0	0	0	8	8
Ewe #4	0	0	0	0	0	0	0	0	0	0	3	3
Lamb #1	0	0	0	0	0	0	0	0	0	0	4	4

* Intermittent fighting was observed between Ram 2 and Ram 4, and between Ram 3 and Ram 4, during the second week in September. Butts exchanged during these fights have not been included in the table because on the two days that these fights occurred the experimenter was occupied with taking motion pictures. However, only one

fight might be said to have ended in favor of Ram 4. This fight was between Ram 4 and Ram 2. Since these fights were associated with sexual excitement in Ram 4 the table as presented is representative of social relations *before* the onset of rutting behavior. Fighting and rutting behavior will be discussed in a later section.

Table IV. The unit of measurement is, of course, arbitrary, but it has the merits of being easily computed from the raw data and of yielding quantitative relationships which are in close agreement with observations made during 12 experiments. Table IV contains data on coordinate-feeding among the rams. Both absolute frequencies and coordinate-feeding ratios indicate that among those pairings in which the possibility of coordinate-feeding existed relatively often its frequency varied widely. The ratios are high for Rams 1 and 2 and Rams 2 and 4, and low for Rams 2 and 3 and Rams 3 and 4. Parallel differences among pairs have already been noted with regard to butts and threats. *Aggressive interactions and food sharing vary together*. But although they are associated, it would be wrong to assume that one is a primary cause of the other. Rather, both are directly related to the amount of social distance between individuals. Social distance is psychological rather than spatial, and is de-

termined by the willingness-for-contact, or tolerance, of the dominant sheep with regard to the subordinate. Lack of unilateral or bilateral aggression between two sheep may be an indication of very low tolerance on the part of the dominant animal. Thus, on the day for which coordinate-feeding data is presented, Rams 3 and 4 were the only rams together at the box for a longer time than Rams 1 and 2 were present together, yet the only aggression between the former individuals was a single threat by Ram 3, and the coordinate-feeding ratio was 4/25. In contrast, Ram 1 threatened or butted Ram 2 sixteen times and received three butts from the latter, while the coordinate-feeding ratio was 16/21.

Quantitative data on coordinate-feeding among the ewes was not obtained because during the experiment on August 11 one or more rams were almost always present at the box. The recorded observations of all 12 experiments show that when no ram was pres-

TABLE III.

Feeding Time Scores of Sheep in Experiment Lasting Two and One-half Hours.*

Periods†	Ram #1	Ram #2	Ram #3	Ram #4	Ewe #1	Ewe #2	Ewe #3	Ewe #4	Lamb #1	Lamb #2	Lamb #3	Lamb #4
I	87°	82°	2	3	1	5	0	3	0	0	0	0
II	27	18	54°	8	6	3	0	0	0	0	0	0
III	0	13	28	18	26°	15	14	3	0	9	5	8
IV	10	26	6	39°	7	0	11	0	0	18	0	0
V	0	0	15	12	0	7	7	0	0	11	0	0
VI	9	9	28	25	14	22°	13	0	0	21	4	0
VII	12	0	5	15	12	0	35°	0	0	36°	0	11
VIII	0	28	1	28	0	16	0	0	0	8	11°	0
IX	0	43	19	19	15	7	3	0	2	1	6	14°
Totals	145	219	158	167	81	75	83	6	2	104	26	33

* This was the only occasion upon which a Bristol recording was made for an entire experiment. The experiment was conducted on August 11, and was the sixth in the series of 12. Time scores were computed from the recorded data by counting for each sheep the number of 10-second periods during which the animal had its head in the box for two seconds or longer. This method of

scoring, while less accurate than the very laborious procedure of counting actual time in seconds, does not introduce a serious bias, in the opinion of the experimenter.

† The total time of two and one-half hours was divided into nine periods of 16.6 minutes each.

° Maximum score for a single period.

TABLE IV.

Incidence of Coordinate-feeding Between Rams During Experiment Lasting Two and One-half Hours.*

Pairings	Frequency of coord-feeding	Highest frequency possible†	Coord-feeding ratio
Rams 1 and 2	16	21	16/21
Rams 1 and 3	1	5	1/5
Rams 1 and 4	1	4	1/4
Rams 2 and 3	3	14	3/14
Rams 2 and 4	8	11	8/11
Rams 3 and 4	4	25	4/25

* Coordinate-feeding between two rams is said to occur when both of these rams obtain feeding scores of 3 or more during a 100-second period, while the other two rams obtain scores of zero (c.f. first footnote to Table III for unit of scoring). The coordinate-feeding data were obtained from the Bristol recordings and synchronized field notes of the feed box experiment on August 11.

† The highest frequency possible is the total number of 100-second periods during which a given ram could have engaged in coordinate-feeding with the dominant ram by virtue of the fact that the dominant ram was (a) the only other ram at the box, or (b) accompanied at the box by a ram subordinate to the ram in question.

ent Ewes 1 and 2 dominated other animals at the box. Food sharing was common among Ewes 1, 2 and 3. The lambs almost never had exclusive possession of the box, and when at the box they showed no overt aggression.⁵ The amount of time that they fed depended on the tolerance of the lambs by the ewes. Hence, differences in the ability of individual lambs to feed are related to differences in ewe-lamb relationships. Field observations furnished ample evidence of the following mother-young relationships: Ewe 3 and Lamb 2, Ewe 1 and Lamb 3, and Ewe 2 and Lamb 4.⁶ The yearling was not associated with a ewe in any observable way, either at the box or in the field.

There is reason to believe that the very high feeding score of Lamb 2 was due to an especially close and permissive relationship with its mother. Lamb 2 usually stood very close to its own ewe at the box, and fed whenever she did. Ewe 3 never butted her lamb, although she did not tolerate other lambs. Lambs 3 and 4, on the other hand, did not stay close to their ewes, and often were not at the box when their ewes were feeding. It will be seen in Table III that the feeding scores of Ewe 3 and Lamb 2 are very similar from period to period. The average difference in scores for the same period is only 2.8. Analysis of the Bristol recordings reveals that, of a total of 20 100-second periods during which Ewe 3 fed, her lamb also fed during 17 periods. In contrast with this, Ewe 1 and Ewe 2 fed about as frequently as Ewe 3, but Ewe 1 shared with her lamb only twice, and Ewe 2 never shared with hers.

The lack of agreement between the dominance status of ewes and their lambs may have been noted. Dominance order among the first-season lambs shows no relation to dominance order among the mothers. Of course the number of sheep is much too small to warrant generalizing, but there are two possible correlates of dominance order among first-season lambs that might be mentioned. First,

⁵ The lambs often shoved each other, but never threatened or butted when at the box.

⁶ Sucking and following were the principal behavioral indications of mother-young relationships during July, August, and September.

it is possible that dominance among these lambs is related to order of birth, so that lambs born in February tend to be dominant over those born in March or later. There is no way of checking this hypothesis in the present study, since the birth dates of individuals are not known. Stewart and Scott (14) have found that age is favorable to dominance in a herd of goats.

A second hypothesis is that the amount of social distance between a ewe and her lamb will have a direct bearing on the dominance status of the lamb. In the case of Ewe 3 and Lamb 2 extreme social closeness is associated with dominance of this lamb over two other lambs born in the same season. On the other hand, the relationship between Ewe 2 and Lamb 4 (the lamb of lowest dominance status) was the weakest of the three mother-young relationships. Ewe 2 was the least willing to share food with her lamb or to be sucked. Further credence is given to this suggestion by Scott's (11) observations of two orphan lambs which were placed with a flock of domestic sheep. He noted that, "Both orphans appeared to show less fighting than the other sheep . . . and the ram was not aggressive toward other males even in the breeding season." The hypothesis could be tested in a large herd by testing dominance interactions among the ewes and among the lambs over a period of time beginning shortly after the birth of the lambs, and making frequent observations of each ewe with her lamb in isolation from the other sheep.

LEADERSHIP

Recent studies indicate that leadership may be a behavioral characteristic quite unrelated to dominance status maintained by fighting. The reports of Darling (5) on red deer, Mills (10) and Davis (6) on Rocky Mountain bighorn sheep, and Scott (11) on domestic sheep, all mention that the usual leader in a herd is an old female. Lack of correlation between leadership and dominance interactions has been noted by Allee et al (1) in a flock of ducks, and Stewart and Scott (14) in a herd of goats.

In the present study, clear instances of

leadership occurred only when the sheep were in a conflict situation involving both a source of attraction and a source of danger in close proximity to each other. The source of attraction was the feed box; danger usually was represented by the presence of a strange person, such as the experimenter. The experimenter discovered that if he stood a few yards behind the box after filling it, the sheep would flock into the center of the field and not advance to feed for several minutes. Finally, Ewe 1 slowly moved forward about ten yards and then halted. Her lamb immediately ran to her. Then the other ewes and lambs, and finally the rams, moved up to her advanced position. If the experimenter withdrew further from the box the process of advancing and halting under the leadership of Ewe 1 might be repeated several times, until the herd finally reached the box. The pattern of advance might vary from day to day, but Ewe 1 always led the others. Sometimes she advanced 15 or 20 yards in front of the herd before they followed her. Sometimes the entire herd moved in single file, with Ewe 1 in the lead and the rams bringing up the rear. The rams rarely came up to the box until Ewe 1 had begun to eat.

Leadership was observed 15 times, always in connection with the feed box experiments. Once the rams dashed ahead of Ewe 1 when she was about five yards from the box, and on two occasions Ewe 2 took the lead after Ewe 1 had led most of the way. But at all other times Ewe 1 moved in advance of the others. There is ample evidence that the sheep were following Ewe 1, rather than just moving toward the feed box. Seven times Ewe 1 did not take the most direct path to the box, but turned and walked at right angles to it for several yards. When she did this, the other sheep continued to follow her just as if she were approaching the box. When no person was in the field, the sheep moved toward the box more or less independently of each other, but the rams still tended to stay behind the ewes.

On general grounds it would be expected that boldness and leadership were related. In the present study there were no opportunities for observing differences in boldness among the ewes. However, the rams did appear to be more timid than the ewes. A lone ram rarely stayed at the box for more than a few seconds. In all likelihood, when he raised his head from the box and saw that the others had left he would quickly run to where they were. On the other hand, a single ewe might continue feeding alone indefinitely. When the zebra, which had been placed in an adjacent enclosure, suddenly galloped toward the fence, the rams were the first to run from the box and the last to return. This was also true when the experimenter intentionally frightened the herd. The zebra frightened the sheep away from the box about eight times, and each time Ewe 1 led them back. Thus there is considerable evidence that the role of Ewe 1 as leader was

not due merely to a greater familiarity with humans.

In the field studies cited above, leadership usually was an important factor in the normal moving about of the sheep and deer. But among the Barbary sheep, instances of leadership were quite rare outside of the special conflict situations described. In wandering and grazing the herd often was scattered widely over most of the field. The rams, ewes and lambs often formed into separate and dispersed sub-groups, yet no consistent leadership was apparent in any one of the subgroupings. What little leading and following there was occurred between lambs and ewes, and between rams and ewes with the onset of sexual activity.

Ewes and lambs. During approximately 80 hours of observation from mid-July to mid-September, each first-season lamb attempted to suck its ewe about 20 or 30 times. The usual duration of sucking was only a few seconds, and often the attempt consisted of a single, brief thrust at the udder. Generally the ewe was passive while the attempt was made. Lamb 4, however, often was rejected by its ewe, even though it tried to suck less often than the others. For a while, in fact, its maternal origin was not clear. The lamb alternated between following Ewe 2 and Ewe 4, and twice tried to suck from Ewe 4. Repeated observations confirmed its relationship with Ewe 2. Sucking was accompanied by a certain amount of following of ewes by their lambs. When the herd rested a lamb often lay beside its ewe. The yearling associated with the other lambs and joined in the general movements of the herd, but did not favor a particular ewe.

Rams and ewes. As the rams began to manifest sexual interest in the ewes they gradually spent more time in the company of the ewes and tended to follow them closely during early morning and evening. Before August 15 relatively little following occurred. Perhaps the following of the ewes by the rams in the conflict situations is, in part, the result of conditioning which develops during the rutting season.

FIGHTING.

The Barbary sheep would seem to fall about half way between the domestic sheep and the bighorn with regard to amount of fighting. Scott (11) mentioned pushing and shoving among domestic sheep competing for food in winter, and some butting between rams following the same ewe in heat. In contrast, Mills (10) stated that fights between big-horn rams in rut might result in "bleeding noses, splintered horn tips, limping, and skull fractures." No complete comparison can be made with the bighorn because the Barbary sheep were not observed during the height of rutting. There were no observable injuries, and it is probable that the fighting witnessed was far less serious than that associated with breeding.

Two main types of fighting occurred

among the Barbary sheep. One type consisted of a series of head-on charges, usually between rams. The sheep walked away 10 or 15 yards, turned, and walked rapidly toward each other, gradually picking up speed and breaking into a run shortly before they collided. Just before impact their heads were lowered and turned slightly to opposite sides. They attempted to meet squarely with their noses crossed. At the beginning of the charge, the sheep got in step and then tried to keep in step until they struck. If one got out of step they broke off the charge and walked away to charge again. Spencer (13) described bouts between bighorn rams which were very similar in detail. He termed such fights "playful" because one ram would not attack if the other was off balance or not prepared. A fight of this type between Ram 1 and Ram 2 continued intermittently for 25 minutes on August 25. Before that time fights had never lasted more than five minutes.

The second type of fighting consisted of close butting, and locking and twisting of horns. Usually the sheep stood head to head, facing in the same or in opposite directions, and engaged their horn tips. Each tried to twist the head of the other by pulling downward and away. Also, attempts were made to hook the belly or the flank. Fighting of this sort might continue for several minutes. It sometimes started at the feed box as a kind of maneuvering for position.

Until mid-August fighting was almost as common among the ewes as among the rams. The usual fight between ewes consisted of a brief exchange of butts, perhaps with locking of horns and twisting. Charges were very rare. Ewes did not fight with rams.

From mid-August until the termination of the study fighting among the rams increased in frequency, duration and vigor, and was connected with sexual excitement. Rams 2 and 4 were the first to show increased pugnacity and sexual behavior. These rams fought with each other and with the other two rams. Sometimes the penis of a fighting ram emerged briefly from its sheath. By September 10 all four rams had reached a high level of sexual arousal and aggressiveness. Most of the fighting took place in the early morning and in the evening, with relatively little aggressive interaction at the feed box or during the matching tests. Even when Ram 4 was beginning rut and displayed strong aggression toward Rams 2 and 3, he remained rather submissive at the feed box. During the final two days at the box, Ram 4 started fights with Rams 2 and 3. He fought with each male about three times, the average duration of fighting being about two or three minutes. But only once, in a contest with Ram 2, did it appear that he had achieved temporary dominance over his opponent.⁷ And only once did Ram 4 achieve dominance

in a paired matching test. His opponent in this test was Ram 2. Possibly in the two experimental situations Ram 4 was inhibited by previous experiences of defeat and subordination. Seward (12) with rats, and Ginsburg and Allee (7) with mice, have shown that an animal could be conditioned to defeat much more readily than to victory. Although they did not study the factor of physical environment, it seems reasonable to expect that aggression would be most strongly inhibited in the place where subordination had been experienced most frequently.

Play fighting was frequent among the lambs. Often in the evening they scrambled about, pushing and butting each other, in order to gain a position on top of the rocky hillock in the center of the field. This activity was similar to the children's game, "king-of-the-hill," and has been reported by Darling (5) as occurring among red deer fawns. Sometimes fighting in lambs had a more serious appearance. Two lambs might butt head-on forcefully and in rapid succession until both seemed quite exhausted. There was one instance of a lamb fighting with an adult. Late in August Ewe 4 butted Lamb 3 and the lamb immediately butted back. A short fight ensued, ending with the lamb's retreating and then attacking Lamb 4.

SEXUAL BEHAVIOR OF THE RAMS.

The first witnessed attempt to mount a female was by Ram 2 on August 10. The ram reared on his hind legs and his penis emerged about three inches from its sheath for a few seconds. The ewe ran off. The ram then tried to mount another ram. Toward the end of August attempted mountings by rams of both rams and ewes were common. This behavior was not observed to occur in the ewes or lambs. Female urine had an excitatory effect upon the rams. The ram sniffed the urines, then curled the upper lip, extended the neck, and tilted the nose in the air. This pattern, according to Spencer (13) is found in bighorns, as well as in other ungulates. Rams sometimes lay on their backs and sucked their penises for short periods. Ejaculation of semen was not observed to occur. Often in the evening, sexual activity and fighting occupied the rams continuously until dark. At no time during observation was a ewe receptive. A ram did not persist in attempting to mount the same ewe. Two tries were usually enough to discourage him. There was no chasing about the field. A ewe had only to walk or run a few yards to get rid of a ram.

DISPLACED AGGRESSION.

One of the most striking behavior patterns observed in the course of this study was that in which a sheep responded to a butt, threat or attack from a dominant sheep by delivering in kind to the nearest subordinate. Such "displaced aggression" might continue chain-wise through three or four

⁷ The butts exchanged have not been included in the data because the experimenter was engaged in taking motion pictures, and so could not take notes.

individuals, each successive one being lower in dominance. Thus a ram might butt a subordinate ram away from a piece of bread, the latter might butt a ewe nearby, and the ewe in turn a lamb. At the feed box Ram 2 often responded to a sharp butt from Ram 1 by circling the box and butting all the sheep in his path. The examples of displaced aggression are too numerous to be listed. The pattern appeared in rams, ewes and lambs with great frequency. There seemed to be only two factors determining which sheep was to receive a displaced attack, physical proximity and lower dominance status. No special relationships between individuals were apparent, other than the usual ones of dominance-subordination. Winslow (15) found displaced aggression in cats made to compete for food.

SUMMARY AND CONCLUSIONS.

1. This study represents an attempt to analyze social behavior and group organization in a small herd of Barbary sheep.

2. Observations and experiments were made on the herd of four rams, four ewes, and four lambs at the New York Zoological Park during the summer of 1947, under conditions with a minimum of human care and interference.

3. In two types of tests it was found that stable relationships of dominance-subordination existed between all individuals, and that the dominance order of all eight sheep was one of straight descent through rams, ewes and lambs.

4. When grain was placed in a small feed box it was found that individual differences in total feeding time at the box were not related to the dominance order. These individual variations probably were due to different rates of food intake and differences in nutritional needs.

5. In the feed box experiments it was found that there was an order of time-of-maximum-feeding which was very similar to the order of dominance.

6. Differences were found in the "social distance" between any two rams when at the feed box. These differences were reflected in the amount of food sharing that occurred and in amount and reciprocity of aggression. Food sharing and aggressive interaction were positively related, and both appeared to be manifestations of the dominant animal's tolerance, or willingness-for-contact with regard to the subordinate.

7. There were individual differences in amount of food sharing and amount of sucking among three ewe-lamb pairs. The dominance status of the lamb seemed to be associated with the social distance between the lamb and its mother. But there appeared to be no relation between the dominance status of the ewe and the dominance status of her lamb.

8. Essential leadership appeared only in conflict situations characterized by a locus

of attraction and a locus of danger in close proximity to each other. In conflict situations a ewe always led, and with only two exceptions it was always the same ewe. The rams were more timid than the ewes in strange and potentially "dangerous" situations.

9. Fighting occurred between rams, ewes and lambs. With one exception, there were no fights between ewes and rams, or between adults and lambs. Ewes fought less than rams, while among lambs play-fighting often was observed.

10. As sexual activity appeared in the rams, fighting became more frequent and vigorous.

11. Dominance relationships between rams remained stable throughout the study and from the time of the first appearance of sexual interest until the study terminated five weeks later.

12. Sexual activity in the rams consisted of attempted mounting of ewes and rams and sometimes of incomplete masturbation. Ewes were not receptive up to September 14, when the study ended.

13. Instances of displaced aggression were very numerous. The recipient was usually the nearest subordinate animal.

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